Space Weather Technical Forecast

Issued on Friday, 17 February 2023 at 13:23 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: G1-G2 Minor/Moderate Storms likely due to CME arrival forecast later day 1 (17th), continuing day 2 (18th). Chance of M-flares throughout (R1/R2 Radio Blackouts).

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Low with a number of C-flares, peaking with a long period C9.0 flare from AR3229 Dho/Beta near the northeast limb. This region is gradually rotating into view, and likely has some shear across its magnetic field lines due to an east to west aligned polarity inversion line. Further complexity may become apparent over the coming 24 hours. There are a total of six sunspot regions on the visible solar disc. The largest AR3226 Eho/Beta has simplified a little, and remains inactive with the other regions generally mature and either stable or declining. Although some small growth has recently been observed in AR3225 Cao/Beta with flux emergence around its trailer. No Earth-directed CMEs have been observed in available imagery in the last 24 hours.

Solar Wind / Geomagnetic Activity: Solar wind speeds continued to be indicative of the fast wind, likely from the partially obscured coronal hole 76. Observed speeds at L1 remained slightly elevated to elevated ranging between 450 and 550 km/s, with density remaining falling from above average to below average. The total IMF strength, Bt, declined from initially strong levels at around 20 nT at around 16/1400 UTC, to be Moderate between 10-16nT until 17/0100 nT, then became weak at around 4-7 nT. The north-south component, Bz, soon rotated from a southward peak of -16nT, to be mainly positive between 16/1430-17/0130 UTC, peaking northward at 12 nT, before becoming weak and variable. Phi angle was mainly positive (away from the Sun). Geomagnetic activity was initially Active (Kp4) 16/1200-1800 UTC, then became Quiet to Unsettled (Kp 0-3).

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) as measured at GOES-16 remained at background levels. High energy electron flux (greater than 2MeV) at GOES16 has been at background levels throughout. The associated 24 hour electron fluence has been below the Active (1e8 integrated pfu) threshold, reaching 2.12e6 integrated pfu at 17/0000 UTC on a slowly increasing trend.

Four-Day Space Weather Forecast Summary

Solar Activity: Moderate to Low activity is forecast through the next four days with a chance of isolated M-flares. The main risk for significant flaring is AR3229 on the northeast limb. A new region is also expected to soon rotate over the southeast limb.

Solar Wind / Geomagnetic Activity: A CME which left the Sun on 15 February is due to arrive at Earth around 17/1800UTC, within +/- 12 hours. Solar winds are expected to be slightly elevated to elevated as this arrives, at around 500 km/s, with ongoing CME effects then persisting day 2 (18th). Enhanced solar winds likely declining day 3 (19th), before a further enhancement then occurs later day 3 or day 4 (20th) due to the arrival of any CIR and the associated fast wind of CH77/+. Geomagnetic activity is expected to be Quiet, isolated Unsettled at first, increasing to Active to G1 Minor Storm, with a chance of G2/Moderate Storms, with the CME arrival later day 1 and likely continuing day 2 (17th and 18th). Activity is then expected to

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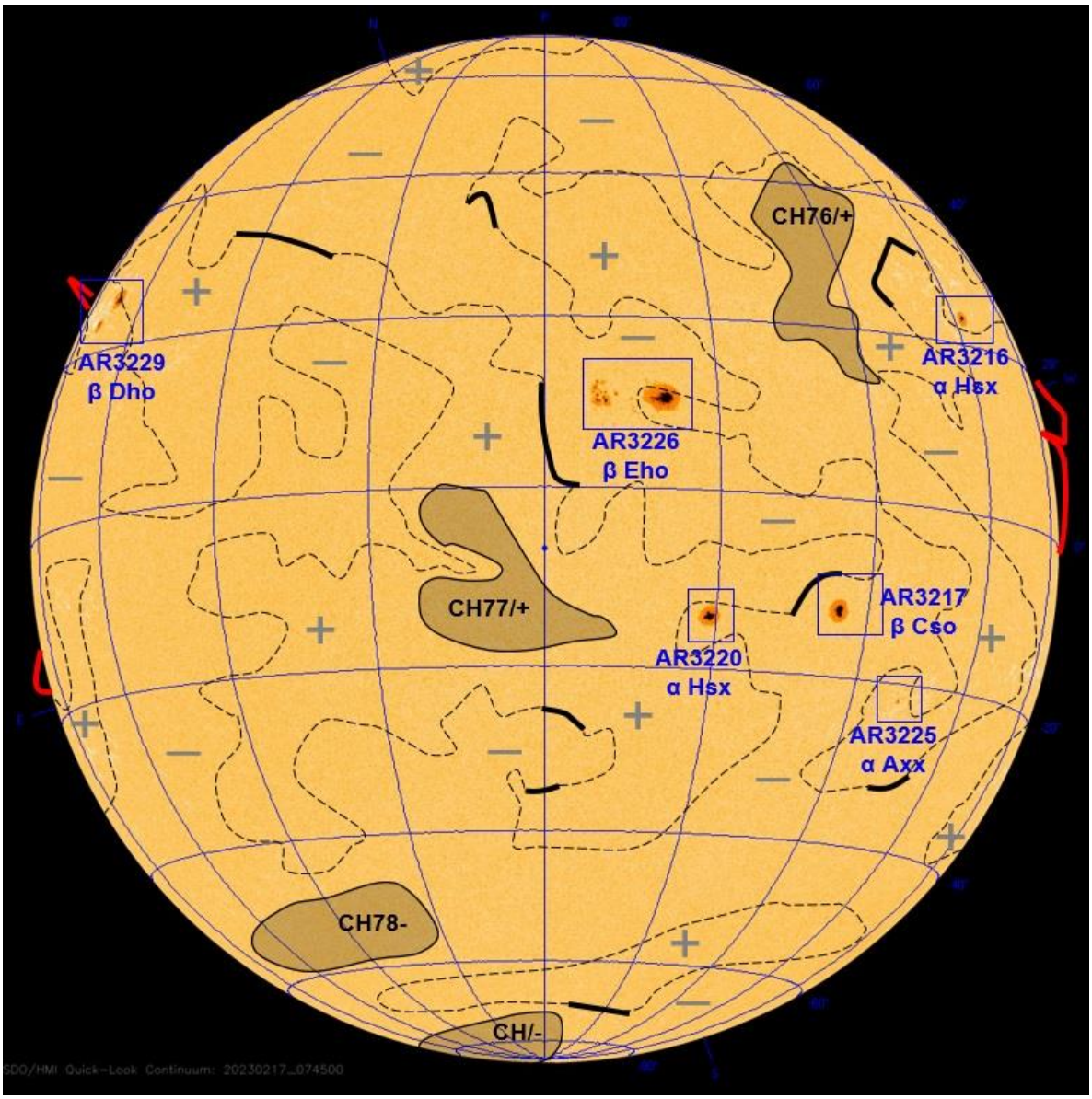
gradually ease day 3 (19th), to Quiet to Unsettled with Active intervals, but still a chance of further G1/Minor storms.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is expected to remain at background levels, but with a slight chance of exceeding S1 in response to any significant flares. High energy (greater than 2 MeV) electron flux may reach high (1e3pfu) levels later in the forecast period, but with low confidence due to potential CME arrivals. The associated 24 hour fluence is expected to remain below the Active threshold (1e8 integrated pfu), but likely rising towards this threshold later in the period.

Figure 1. Solar Analysis Valid 17/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

A CME from a filament eruption, just east of the central solar disc is forecast to arrive at 17/1800 UTC +/- 12 hours. This timing of the arrival is only of moderate confidence due limited available imagery for analysis, resulting in a wide range of potential CME speeds. A fast CME from filament eruption and associated C9 flare off the northwest disc (near AR3216) on the 15th, has also been assessed as missing, however this is being reviewed as there may be some potential for a glancing impact on the 18th (day 2). This could combine, or be indistinguishable from the ongoing CME influence, but may increase geomagnetic activity further.

Current slightly elevated to elevated solar winds are due Earth moves through the fast wind originating from a partially obscured coronal hole (CH76) in the northwest disc. The expected CME arrival is likely to limit the easing of the winds on day 1 and day 2 (17th and 18th), before any CME and CH combined influence recedes day 3 (19th). However, CH77/+ in the centre disc is then likely to enhance solar winds from either late day 3 or day 4 (19th or 20th), resulting in the slightly elevated to elevated winds persisting.

Geomagnetic activity is expected to be Quiet, isolated Unsettled at first, increasing to Active to G1 Minor Storm, with a chance of G2/Moderate Storms, with the CME arrival later day 1 and likely continuing day 2 (17th and 18th). Activity is then expected to gradually ease day 3 (19th), to Quiet to Unsettled with Active intervals, but still a chance of further G1/Minor storms from either ongoing CME effects or any enhancement from CH77.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	60	60	30	10
Strong	G3	No	10	10	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
15/1128	Partial	Filament	12E 10S	650 km/s	17/1800 +/- 12 hrs	Moderate confidence for timing, with broad range of speeds possible.

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Figure 2a: Enlil and Ensemble, showing spread of arrival times for CME on 17th.

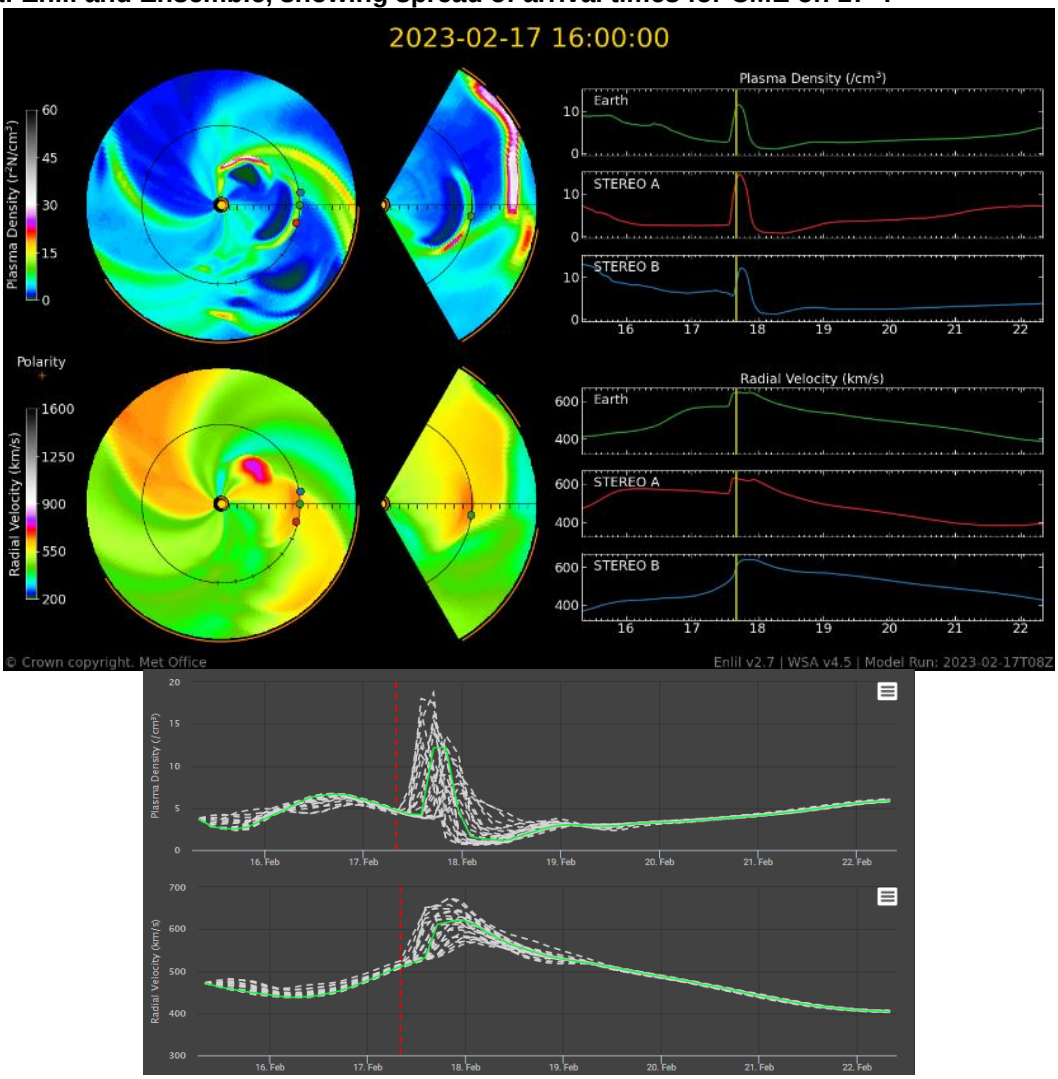
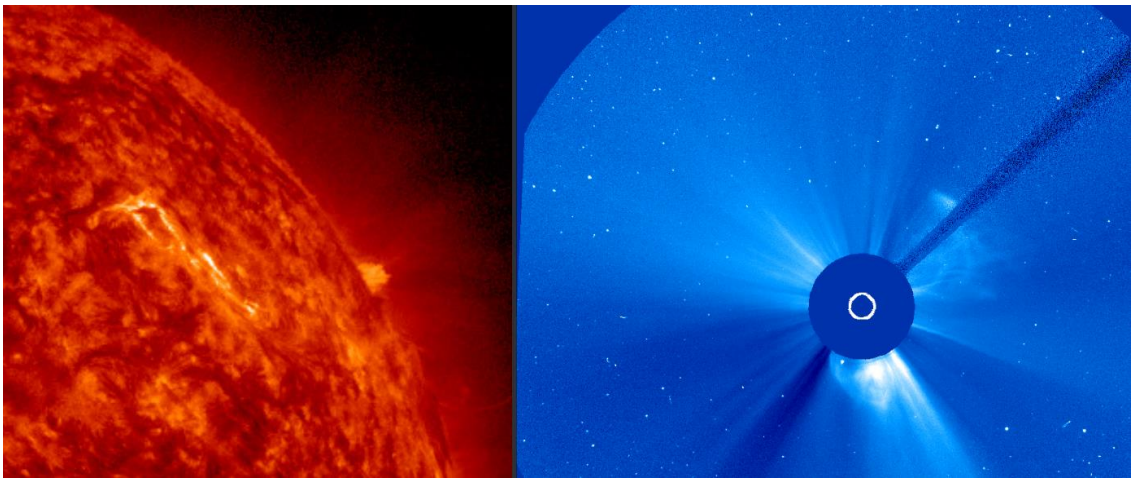


Figure 2b: SDO aia-304 and SOHO LASCO C3, showing CME off the NW due to a filament eruption on the 16th. This is forecast to miss, but currently being reviewed for any potential glancing influence.



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Radio Blackouts - X-Ray Flares:

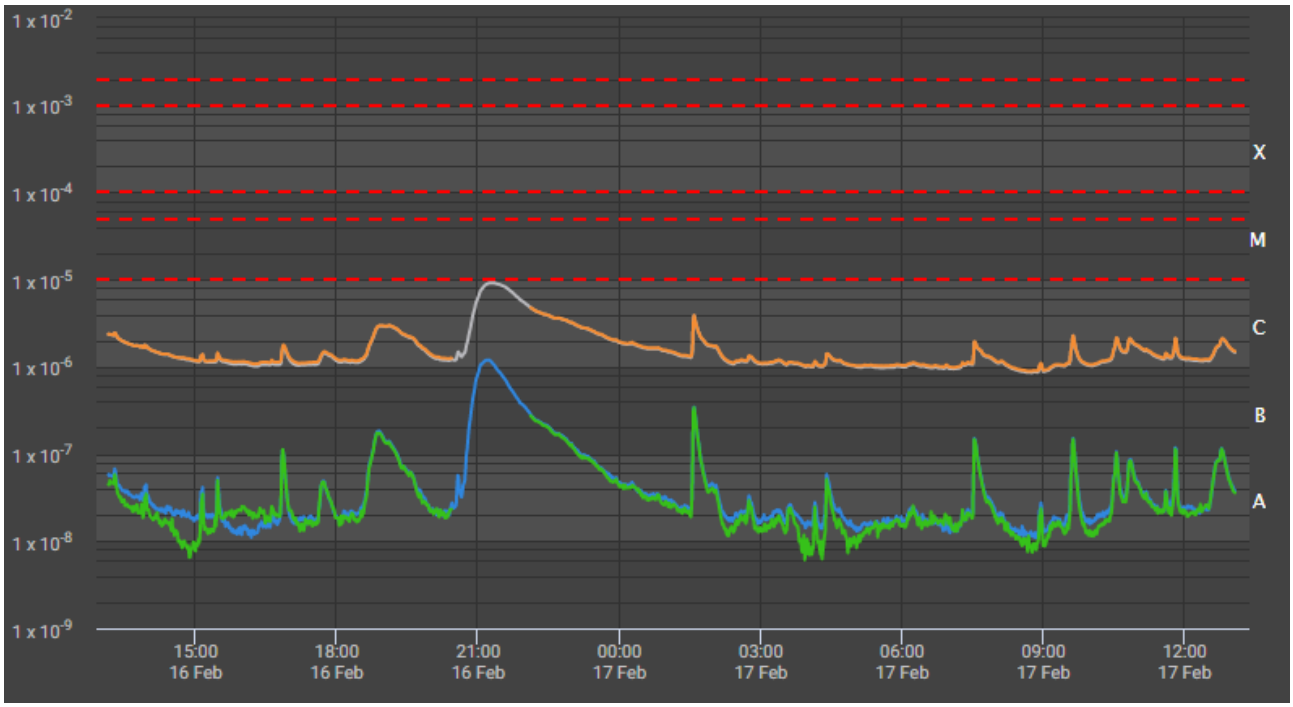
Solar activity is expected to be Moderate to Low, with a risk of M-class flares.

There are six sunspot regions on the earth-facing disc, however the majority of these are simple, stable and mature regions with little sign of development. This includes the largest region AR3226 Eho/Beat just west of the north-centre disc, which is a large bipolar region that has recently simplified losing its delta spot. With a north-south aligned magnetic inversion line, the spot is expected to remain stable unless any further growth is observed.

The main flare interest is likely to originate from the smaller northeastern limb region AR3229 Dho/Beta. With its east-west aligned inversion line, some notable looping visible on SDO imagery (e.g. aia-171) and the potential for further complexity to become visible as it rotates into view, this gives a chance of M-class flares. STEREO A euvi imagery also indicates a region likely to rotate onto the southeast limb later on day 1 or during day 2 (17th and 18th), also increasing the chance of X-ray flares.

X Ray Flares Probability	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	R1-R2 M Class	No	40	40	40	40
Very Active	R3 to R5 X Class	No	5	5	5	5

Figure 3: GOES-16/18 X-ray flux



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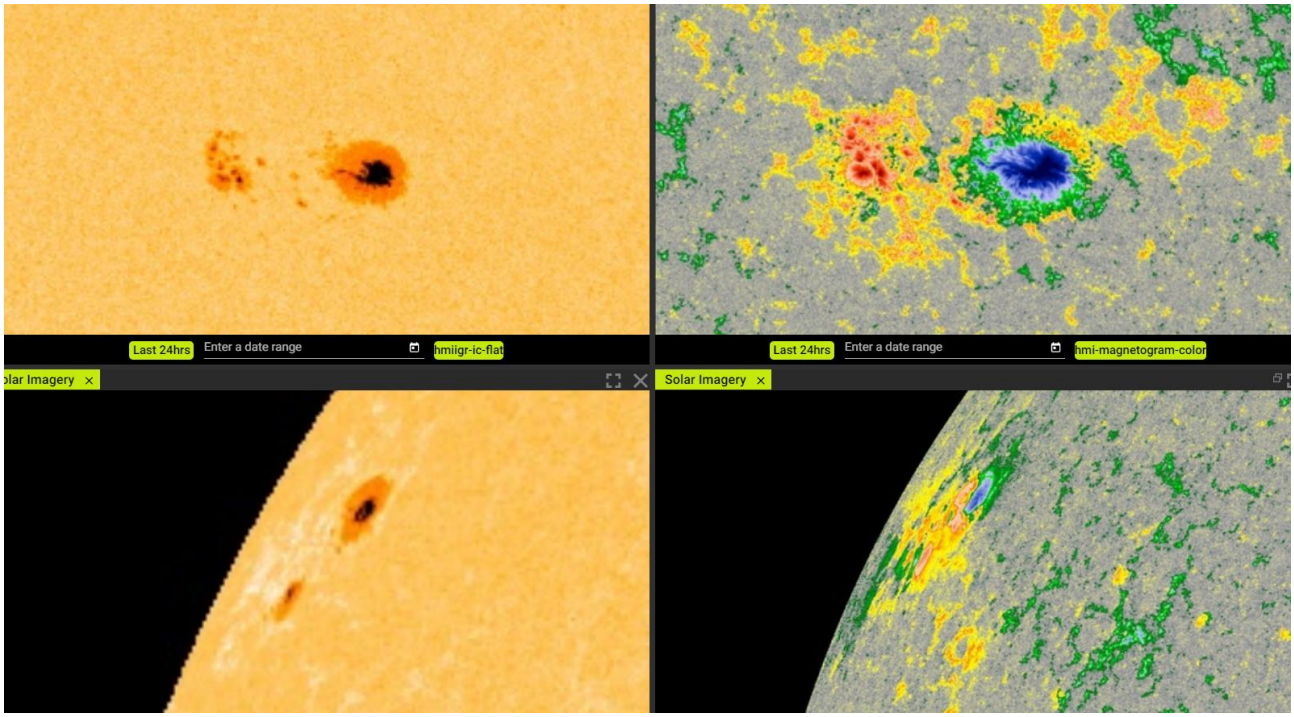
Solar Radiation Storms - (High Energy Protons):

High energy (greater than 10MeV) proton flux, as observed by GOES16, is currently at background levels and expected to remain at this level.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	1	1	1	1
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: SDO Intensitygram and Magnetogram of AR3226 (top) and AR3229 (bottom)



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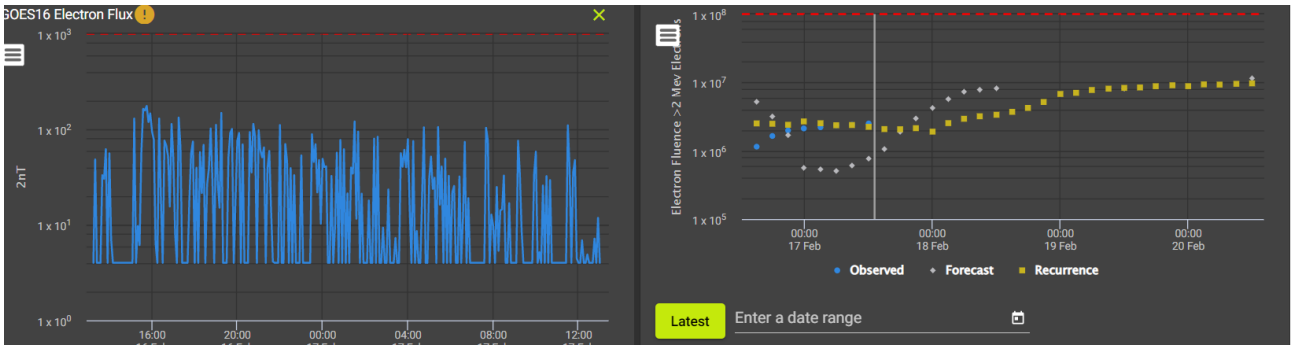
High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) observed at GOES-16 are currently background, however the recent fast wind enhancement, along with CME arrivals on previous days, has likely increased count rates at lower orbits. As elevated solar winds decline these increased rates have the potential to expand towards GEO. However, any observed increase in flux is expected to become limited by the forecast CME arrival later day 1 (17th), with effects continuing day 2 (18th). This could potentially result in a drop out of observed flux with any subsequent recovery also remaining lower confidence. By day 3 or day 4 (19th-20th), Moderate flux, with a slight chance of High, is possible but this is also likely to become suppressed as any CIR region arrived ahead of the fast winds of coronal hole 77.

The associated 24 hour fluence is expected to remain below the Active threshold, with only a slight chance of rising above, mainly day 3 and 4 (19th and 20th). REFM maintains below Active fluence, and this is likely to be a reasonable guide through the period.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	5	10	10
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 5: >2MeV Electron Flux (left) and associated Fluence with REFM (right)



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